01 an error rate determination device that allocates a symbol error rate or bit error rate to a calculated signal-to-noise ratio.

REMARKS

The present Amendment revises the specification and claims to conform to United States patent practice, before examination of the present PCT application in the United States National Examination Phase. Pursuant to 37 CFR 1.125 (b), applicants have concurrently submitted a substitute specification, excluding the claims, and provided a marked-up copy. All of the changes are editorial and applicant believes no new matter is added thereby. The amendment, addition, and/or cancellation of claims is not intended to be a surrender of any of the subject matter of those claims.

Early examination on the merits is respectfully requested.

Submitted by,

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Appendix A
Mark Ups for Claim Amendments

This redlined draft, generated by CompareRite (TM) - The Instant Redliner, shows the differences between -
original document : Q:\DOCUMENTS\YEAR 2001\P010086-EICHINGER\ORIGINAL CLAIMS.DOC
and revised document: Q:\DOCUMENTS\YEAR 2001\P010086-EICHINGER\AMENDED CLAIMS.DOC

CompareRite found 194 change(s) in the text

Deletions appear as Overstrike text surrounded by []
Additions appear as Bold-Underline text

1. [~~Method~~]**(Amended)** **A method** for measuring [~~the~~] **a** transmission quality of a transmission channel [~~(4)~~] via which an information is transmitted, **comprising the steps of:** [~~whereby the transmitter implements the following steps:~~
~~--~~]

representing [~~the~~] **said** information [~~in the form of~~] **as** symbols**;**[~~,~~
~~--~~]

mapping [~~the~~] **said** symbols onto signal values**;** and

[~~--~~]transmitting [~~the~~] **said** signal values via [~~the~~] **said** transmission channel[~~(11);~~]**, forming transmitted signal values;**

[~~whereby the~~] **wherein said** receiver implements the [~~following~~] steps **of:**[~~:~~
~~--~~]

receiving [~~the~~] **said** transmitted signal values**, forming**[~~(14),~~
~~-- mapping the~~] received signal values[~~(21)~~]**;**

mapping said received signal values onto detected symbols[~~(9)~~]**;** and

[~~--~~]converting [~~the~~] **said** detected symbols [~~(9)~~] into a detected information; and [~~whereby the~~] **wherein a** measuring [~~method~~] comprises the [~~following~~] steps **of:**[~~:~~
~~--~~]

forming a reference signal [~~(15)~~] by mapping successive, detected symbols [~~(9)~~] onto signal values**;** and

[~~--~~]calculating [~~the~~] **said** transmission quality [~~(22, 23)~~] of [~~the~~] **said** transmission channel [~~(4)~~] based on [~~the~~] **said** reference signal [~~(15)~~] and on [~~the~~] **said** received signal values[~~(14)~~].

2. [~~Method~~]**(Amended)** **The method** according to claim 1, [~~characterized in that the step for the calculation of the~~] **wherein said step of calculating said** transmission quality [~~(22) implements~~] **comprises** the [~~following~~] steps **of:**[~~: --~~]

determining a noise signal part [~~(27)~~] of [~~the~~] **said** received signal values [~~(14)~~] upon employment of [~~the~~] **said** reference signal**; and**[~~(15); --~~]

calculating the transmission quality [~~(22)~~] of the transmission channel [~~(4)~~] based on [~~the~~] **said** reference signal [~~(15)~~] and [~~the~~] **said** noise signal part[~~(27)~~].

3. [~~Method~~]**(Amended)** **The method** according to claim 2, [~~characterized in that, for~~] **wherein said step of** calculating [~~the~~] **said** transmission quality **further comprises the steps of:**

determining an[~~, -- the~~] average power [~~(S, N)~~] of [~~the~~] **said** reference signal [~~(15)~~] and of [~~the~~] **said** noise signal part [~~is determined; and~~]**; and**

[~~-- to~~] **calculating a** signal-to-noise ratio [~~(22) is calculated as~~]**as a** criterion for [~~the~~] **said** transmission quality based on [~~the~~] **said** average power [~~(S)~~] of [~~the~~] **said** reference signal [~~(15)~~] and on [~~the~~] **said** average power [~~(N)~~] of [~~the~~] **said** noise signal part.

4. [~~Method~~]**(Amended)** **The method** according to claim 2 [~~or claim 3, characterized in that the average power (N) of the noise signal part is calculated by~~]**,** **wherein said step of calculating said transmission quality further comprises the step of:**

determining [~~the~~] **an** average power of [~~the difference of the~~] **said reference signal and of said noise signal part, said step of determining said average power of said noise signal part comprises calculating an average power of a difference of said** received signal values [~~(14)~~] and [~~the~~] **said** reference signal[~~(15).~~]**.**

[~~5. Method~~] **5. (Amended) The method** according to claim 2 [~~or claim 3, characterized in that the average power (N) of the~~]**, wherein said step of calculating said transmission quality further comprises the step of:**

determining an average power of said reference signal and of said noise signal part [~~is~~]**, said average power of said noise signal part being** determined by forming [~~the~~] **a** difference of [~~the~~] **said** average power [~~(S+N)~~] of [~~the~~] **said** received signal values [~~(14)~~] and [~~the~~] **said** average power [~~(S)~~] of [~~the~~] **said** reference signal[~~(15).~~]**.**

[~~6. Method~~] **6. (Amended) The method** according to [~~one of the claims 3 through 5, characterized in that~~] **claim 3, further comprising the step of allocating** a symbol error rate [~~(23)~~] or **a** bit error rate [~~is allocated to the~~] **to said** calculated signal-to-noise ratio [~~(22)~~] for specifying a measured value for [~~the~~] **said** transmission quality.

7. [~~Transmission~~]**(Amended) A transmission** system for [~~the transmission of~~] **transmitting** digital information, comprising**:**

a transmitter **comprising:**[~~(10) that contains:~~

~~-~~]

an encoding device for representing [~~the~~] **said** digital information [~~in the form of~~] **as** symbols[~~,~~]**;** and

[

~~-~~]a modulator for mapping [~~the~~] **said** symbols onto signal values for [~~the~~] **said** transmission via a transmission channel[~~(4);~~]**;**

[~~and comprising~~] a receiver **comprising:**[~~(12) that contains:~~

--]

a demodulator [~~(20)~~] for mapping received signal values [~~(14)~~] onto detected symbols[~~(9)~~]; and

[

--]a decoding device [~~(24)~~] for representing [~~the~~] **said** detected symbols [~~(9)~~] as detected digital information;

and

[~~comprising~~] a device for measuring [~~the~~] **a** transmission quality of [~~a~~] **said** transmission channel [~~(4)~~] for [~~the~~] **said** transmission of digital information[~~, whereby said device contains:~~

--] **comprising:**

a modulator for generating a reference signal[~~(15)~~], in that signal values are allocated to successively detected symbols[~~(9),~~]**;** and

[--]a transmission quality determination device [~~(11)~~] for determining [~~the~~] **said** transmission quality [~~(22, 23)~~] of [~~the~~] **said** transmission channel [~~(4)~~] based on [~~the~~] **said** reference signal [~~(15)~~] and on [~~the~~] **said** received signal values[~~(14).~~]**.**

[~~8. Apparatus~~] **8. (Amended) The transmission system** according to claim 7, **further comprising:** [~~characterized in that the apparatus also comprises:~~

--]

a device [~~(24)~~] for determining [~~the~~] **a reference signal** average power [~~(S)~~] of [~~the~~] **said** reference signal**;**[~~(15),~~

--]

a device [~~(29)~~] for determining [~~the~~] **a received signal value** average power [~~(S+N)~~] of [~~the~~] **said** received signal values**;**[~~(14),~~

--]

a subtractor [~~(30)~~] for subtracting [~~the~~] **said reference signal** average power [~~(S) of the reference~~] **from said received** signal [~~(15) from the~~] **value** average power

[~~(S+N) of the received signal values (14)~~] and for generating [~~the~~] **a noise signal part** average power [~~(N)~~] of a noise signal part[~~,~~]**;** and

[~~--~~]a divider [~~(28)~~] for calculating [~~the~~] **a** signal-to-noise ratio [~~(22)~~] as **a** criterion for [~~the~~] **said** transmission quality by division of [~~the~~] **said reference signal** average power [~~(S) of the reference signal (15) by the average power (N) of the~~] **by said** noise signal part **average power.**

9. (Amended) The transmission system[~~.~~

~~9. Method~~] according to claim 7, **further comprising:** [~~characterized in that the apparatus also comprises:~~

~~--~~]

a device [~~(24)~~] for determining [~~the~~] **a reference signal** average power [~~(S)~~] of [~~the~~] **said** reference signal**;**[~~(15),~~

~~--~~]

a subtractor [~~(26)~~] for subtracting [~~the~~] **said** reference signal [~~(15)~~] from [~~the~~] **said** received signal values [~~(14)~~] and for generating a noise signal part**;**[~~,~~

~~--~~]

a device [~~(25)~~] for determining [~~the average power (N) of the~~] **a** noise signal part[~~, and~~

~~--~~] **average power of said noise signal part; and**

a divider [~~(28)~~] for calculating [~~the~~] **a** signal-to-noise ratio [~~(22)~~] as **a** criterion for [~~the~~] **said** transmission quality by dividing [~~the~~] **said reference signal** average power [~~(S) of the reference signal (15) by the average power (N) of the~~] **by said** noise signal part **average power.**

10. (Amended) A transmission system[~~.~~

~~10. Apparatus~~] according to [~~one of the claims 7 through 9, characterized in that the apparatus also comprises~~] **claim 7, further comprising:**

an error rate determination device [~~(12)~~] that allocates a symbol error rate [~~(23)~~] or bit error rate to a calculated signal-to-noise ratio[~~(22)~~].

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original document : Q:\DOCUMENTS\YEAR 2001\P010086-EICHINGER\ORIGINAL SPEC.DOC
and revised document: Q:\DOCUMENTS\YEAR 2001\P010086-EICHINGER\SUBSTITUTE SPECIFICATION.DOC

CompareRite found 138 change(s) in the text

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SPECIFICATION

TITLE

METHOD AND APPARATUS FOR MEASURING THE TRANSMISSION QUALITY OF A TRANSMISSION CHANNEL

BACKGROUND OF THE INVENTION

Field of the Invention

1 The invention is directed to a method and to a corresponding apparatus for measuring the transmission quality in a transmission of digital information via a transmission channel.

Description of the Related Art

2 The need for digital transmission systems has exponentially risen in recent decades. Digital transmission systems are generally classified into the function units shown in Fig. 1. A message source 1 generates information that is transmitted by a transmitter via a transmission channel 4 to a receiver. The properties of the information to be transmitted are dependent on the message source. Messages to be transmitted can, for example, be an audio signal or a video signal. [~~Analog transmission signals thereby transmit~~] **The message source transmits** analog signals that were generated by analog message sources, transmitting these directly via the transmission channel upon employment of traditional analog modulation methods. Such modulation methods are, for example, amplitude modulation, frequency modulation or phase modulation. In digital transmission systems, the information to be transmitted is converted into a sequence of binary numbers. In order to be able to utilize the capacity of the channel optimally well, the message to

be transmitted ~~[should be]~~ **is generally** represented with as few binary numbers as necessary. ~~[To this end, a]~~ **A** source encoder is ~~[employed that has the job of converting]~~ **used to convert** the messages to be transmitted into sequences of signal values and ~~[encoding]~~ **encode** them~~[,]~~ so that the channel can transmit them. The source encoder ~~[thereby]~~ attempts to convert the messages to be transmitted into binary numerals as efficiently as possible. The sequence of binary numbers generated by the source encoder is transmitted by the channel to the receiver. Such an actual channel can, for example, be composed of **transmission media such as** a line connection, ~~[of]~~ a coaxial cable, ~~[of]~~ a light waveguide (LWL), ~~[of]~~ a radio connection, a satellite channel or a combination of these ~~[transmission media]~~. Such channels cannot directly transmit the sequence of binary numbers from the transmitter. ~~[To that end, the]~~ **The** sequence of digital information must be converted into signal values that correspond to the properties of the channel~~[. Such]~~**, using** a device ~~[is]~~ called a digital modulator. Such a modulator is part of the channel encoder 3, which additionally comprises a discrete channel encoder in order to provide the information to be transmitted with an error protection adapted to the channel.

~~[It]~~ **3** **The transmission channel 4** is not assumed ~~[of the transmission channel 4 that it works]~~ **to work** error-free; rather, it is assumed that a noise source 5 will modify the transmitted signals during the transmission with a specific probability.

4 Such disturbances can, for example, be a cross-talk of signals that are transmitted on neighboring channels. The disturbances can likewise be caused by thermal noise that is generated in the electronic circuit such as~~[, for example,]~~ amplifiers and filters that are employed in the transmitter and in the receiver. Given line connections, disturbances can additionally be caused by ~~[switchings]~~ **switching** and can be additionally caused by meteorological influences given radio or satellite connections such as~~[, for example,]~~ thunderstorms, hail or snow. Such influences modify the transmitted signal and cause errors in the received digital signal sequence.

5 In order to nonetheless assure a relatively dependable transmission, the channel encoder increases the redundancy of the (binary) sequence to be transmitted. With the assistance of this redundancy added by the transmitter, the receiver is assisted in the decoding of the information-carrying signal sequence. To

this end, for example, the channel encoder combines a specific plurality of signals to form blocks and a plurality of check signals (one parity bit in the simplest case) is added. In this way, k information bits are always simultaneously encoded, ~~[whereby]~~ **where** each k bit sequence has an unambiguous n bit sequence~~[, what is referred to as the code word,]~~ **("code word")** allocated to it. The redundancy added in this way can be indicated with the ratio n/k. This likewise corresponds to the channel bandwidth that must be correspondingly increased in order to transmit the information sequence expanded by the added redundancy.

6 Alternatively, an enhanced dependability against channel disturbances can also be achieved, for example, by an increase in the transmission power. Since the increase in the transmission power, however, is relatively expensive, the dependability is usually achieved given available bandwidth by increasing the required channel bandwidth.

7 In the transmission of one bit with the data rate R bit/s, the modulator always allocates a signal curve or~~[, respectively,]~~ a signal value (referred to below only as signal value) $s_1(t)$ to the binary number 0 and allocates a signal value $s_2(t)$ to the binary number 1. This transmission of each individual bit by the channel encoder is called binary modulation. Alternatively, the modulator can simultaneously transmit k information bits ~~[upon employment of]~~ **using** $M = 2^k$ different signal values $s_1(t)$ with i = 1, 2, ... M, ~~[whereby]~~ **where** each of the 2^k possible k-bit sequences is allocated to a signal value.

8 At the receiver side of a digital transmission system, the digital demodulator processes the signal value transmitted in the channel (potentially modified) and allocates an individual number to each signal value that represents an estimate of the transmitted data symbol (for example, binary).

9 After reception of a signal in the receiver, the demodulator must decide which of the M possible signal values was sent. This decision is implemented in a decision unit (slicer)~~[, whereby]~~ **in which** the decision ~~[should be]~~ **is** made with minimal error probability. This decision unit allocates a reception value (usually edited) to one of the M possible symbol values.

10 When, for example, a binary modulation is employed, the demodulator must decide when processing each received signal whether the transmitted bit is a ~~[matter of a 0 or of a 1. In this case]~~ **0 or 1, i.e.**, the demodulator implements a binary

decision. Alternatively, the demodulator can also implement a ternary decision, ~~[whereby]~~ **where** the demodulator decides for "0", "1" or "no decision" ~~[dependent]~~ **depending** on the quality of the received signal.

11 The decision process of a demodulator can be viewed as quantization, ~~[whereby]~~ **where** binary and ternary decisions are specific instances of a demodulation that quantizes Q-~~[level, whereby]~~ **levels, where** Q ≥ 2 applies. In general, digital communication systems employ a high-order modulation, ~~[whereby]~~ **where** m = 0, 1 ... M-1 represents the possible transmitted symbols.

12 When the transmitted information contains no redundancy, the demodulator must decide at every predetermined time interval which of the M-signal values was transmitted. When the transmitted information, in contrast, contains redundancy, then the demodulator reconstructs the original information sequence on the basis of the code employed by the channel encoder and on the basis of the redundancy of the received signals. Dependent on the demands defined by the applications, the channel encoder generates signal blocks that make it possible for the channel decoder to either only identify where the specific disturbances have occurred (error-recognizing encoding) or to even be able to automatically correct (error-correcting encoding) errors caused by disturbances (up to a specific maximum number per signal block).

13 One criterion for the dependability with which the messages are transmitted from the transmitter to the receiver is represented by the error rate. The error rate indicates the average probability with which a bit error occurs at the output of the decoder. The bit error rate indicates the plurality of error bits occurring at the receiver divided by the total number of received bits per time unit. The bit error rate (or symbol error rate when the error frequency of symbols is evaluated) is the most important quality criterion of a digital transmission system. In general, the error probability is dependent **1)** on the code properties, **2)** on the nature of the signal values employed for the transmission of the information via the channel, **3)** on the transmission power, **4)** on the properties of the channel, i.e.**,** the strength of the noise, the type of noise, etc., and **5)** on the demodulation and decoding method. The significance of the bit error rate for digital transmission systems corresponds to the signal-to-noise ~~[ration]~~ **ratio** (SNR) of analog transmission systems.

14 Traditionally, a known bit sequence or~~[, respectively,]~~ symbol sequence is transmitted at periodic time intervals for determining the error rate~~[, being]~~**. This known bit sequence is** transmitted in addition to the transmitted information and also ~~[be]~~ is known to the receiver. Such a signal is generally composed of a pseudo-random sequence of suitable length. The error rate can be determined in the receiver in that a comparison of the transmitted signal to the received signal is implemented (rated-actual comparison).

SUMMARY OF THE INVENTION

15 An object of the invention is to create an improved method and an improved apparatus for measuring the transmission quality of a digital transmission channel.

16 This object is achieved ~~[for a method with the technical teaching of claim 1 and is achieved for an apparatus with the technical teaching of claim 7.]~~ **with a method for measuring a transmission quality of a transmission channel via which an information is transmitted, comprising the steps of representing the information as symbols; mapping the symbols onto signal values; and transmitting the signal values via the transmission channel, forming transmitted signal values; wherein the receiver implements the steps of: 1) receiving the transmitted signal values, forming received signal values; 2) mapping the received signal values onto detected symbols; and 3) converting the detected symbols into a detected information; and wherein a measuring comprises the steps of: 1) forming a reference signal by mapping successive, detected symbols onto signal values; and 2) calculating the transmission quality of the transmission channel based on the reference signal and on the received signal values.**

~~[Advantageous]~~ **17** **This object is also achieved by a transmission system for transmitting digital information, comprising a transmitter, a receiver, and a device for measuring a transmission quality of the transmission channel for the transmission of digital information. The transmitter comprises an encoding device for representing the digital information as symbols; and a modulator for mapping the symbols onto signal values for the transmission via a transmission channel. The receiver comprises a demodulator for mapping received signal values onto detected symbols; and a decoding device**

for representing the detected symbols as detected digital information. The device for measuring a transmission quality of the transmission channel for the transmission of digital information comprises a modulator for generating a reference signal, in that signal values are allocated to successively detected symbols; and a transmission quality determination device for determining the transmission quality of the transmission channel based on the reference signal and on the received signal values.

18 **Further** developments of the [~~invention are recited in the subclaims.~~]**method include steps of determining a noise signal part of the received signal values upon employment of the reference signal; and calculating the transmission quality of the transmission channel based on the reference signal and the noise signal part. The step of calculating the transmission quality may further comprise the steps of determining an average power of the reference signal and of the noise signal part; and calculating a signal-to-noise ratio as a criterion for the transmission quality based on the average power of the reference signal and on the average power of the noise signal part. The step of calculating the transmission quality may also further comprise the step of determining an average power of the reference signal and of the noise signal part, the step of determining the average power of the noise signal part comprises calculating an average power of a difference of the received signal values and the reference signal. The step of calculating the transmission quality may further comprise the step of determining an average power of the reference signal and of the noise signal part, the average power of the noise signal part being determined by forming a difference of the average power of the received signal values and the average power of the reference signal. Finally, a step of allocating a symbol error rate or a bit error rate to the calculated signal-to-noise ratio for specifying a measured value for the transmission quality may also be provided.**

19 **The inventive transmission system may further comprise a combination of a device for determining a reference signal average power of the reference signal; a device for determining a received signal value average power of the received signal values; a subtractor for subtracting the reference signal average power from the received signal value average power and for**

generating a noise signal part average power of a noise signal part; and a divider for calculating a signal-to-noise ratio as a criterion for the transmission quality by division of the reference signal average power by the noise signal part average power. The inventive transmission system may also further comprise a combination of a device for determining a reference signal average power of the reference signal; a subtractor for subtracting the reference signal from the received signal values and for generating a noise signal part; a device for determining a noise signal part average power of the noise signal part; and a divider for calculating a signal-to-noise ratio as a criterion for the transmission quality by dividing the reference signal average power by the noise signal part average power. Finally, the inventive transmission system may further comprise an error rate determination device that allocates a symbol error rate or bit error rate to a calculated signal-to-noise ratio.

20 **The elements of the invention are explained in greater detail below.**

21 Inventively, a signal value is again allocated to each detected symbol in the demodulator at the receiver side, namely a signal value that the input of the decision unit in the demodulator would have received if the signal curve or[~~, respectively,~~] signal value corresponding to the detected signal had been transmitted [~~unfalsified~~] **unmodified/unfalsified**. In this way, a hypothetical input signal corresponding to the detected symbol values is formed that contains no signal values with channel distortions. This reference signal, as long as the decision unit does not detect false symbols, thus corresponds to the original signal at the transmission side. By subtracting this reference signal from the actually received signal, the noise signal can be acquired. With the assistance of these two signal parts, the quality of the transmission channel can be defined. The average power of this reference signal formed in this way thus corresponds to the average power of the received, undisturbed signal part. The average power of the received signal corresponds to the combination of disturbed and undisturbed signal parts. With the assistance of the previously calculated, undisturbed signal part[~~,~~] **(**the reference signal[~~,~~]**)** the noise power is calculated [~~therefrom~~] **from it**. The signal-to-noise ratio (SNR) derives from the ratio of the average power of the undisturbed signal part to the average power of the noise part, deriving as a criterion for the transmission quality of the transmission channel.

22 What this invention particularly avoids is that the receiver must know a specific transmission sequence, as **is** necessary in traditional methods. Moreover, the determination of the error rate ensues **in** parallel with the evaluation of the transmitted symbols, i.e.**,** online. A periodic introduction of a measuring sequence into the data stream to be transmitted is therefore no longer required for the continuous measurement of the transmission quality. [~~In this way,~~] **This avoids** a reduction of the net data rate of the transmission channel [~~can be avoided.~~]**.**

23 In order to assure a high statistical dependability, the traditional method that employs a test sequence known to the transmitter and receiver must acquire a great [~~plurality~~] **number** of errors, usually a few hundred. For the extremely low bit error rates of, for example, 10^{-9} that are generally required, the traditional methods need very long measuring times in order to detect a corresponding [~~plurality~~] **number** of errors. The inventive method, in contrast, is based on the interpretation of the measured signal-to-noise ratio during the ongoing transmission. Since, however, significantly shorter measuring times are required for the interpretation of the average powers than for the comparable evaluation of the symbol stream or, respectively, bit stream of the test sequences, the transmission quality can be identified far, far faster with the inventive method.

24 The invention thus enables a monitoring of the actual error rate at noticeably shorter time intervals since the actually transmitted information cannot be employed traditionally for determining the error rate and, thus, one must wait for the occurrence of transmission errors in the test sequences that are only rarely introduced.

25 In a further development of the invention, the identified transmission quality, the signal-to-noise ratio (SNR), can be converted into a symbol or, respectively, bit error rate dependent on the respectively employed encoding method.

BRIEF DESCRIPTION OF THE DRAWINGS

26 Preferred exemplary embodiments of the invention are explained next with reference to the [~~drawing. Shown are:~~] **drawings.**

Fig. 1 **is a block diagram of** the general structure of a message transmission system;

Fig. 2 **is a block diagram showing** the structure of an inventive receiver;

Fig. 3 **is a block diagram showing** the structure of an inventive demodulator of the receiver shown in Fig. 2;

Fig. 4 **is a block diagram showing** the structure of devices for determining the transmission quality of the transmission channel in the receiver shown in Fig.2;

Fig. 5 **is a block diagram showing** a device for allocating an identified transmission quality to an error rate in the receiver shown in Fig. 2 [~~; and~~] **and providing a graph of the symbol error rate as a function of the signal to noise ratio; and**

[~~Fig. 6 a diagram~~] **Fig. 6 is a graph** of characteristics for the allocation of a signal-to-noise ratio to the probability of a symbol error dependent on the modulation method employed.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

27 In digital information transmission, information are transmitted between a message source (transmitter) and a receiver via a transmission medium. Such an apparatus that is located between the transmitter and the receiver is generally referred to as **a** channel.

28 For the transmission, the data to be transmitted are converted into code words that are matched to the transmission properties of the message channel in order to protect the data to be transmitted against, among other things, transmission errors.

29 In the transmission, a character[~~,~~] **(**which is generally referred to as **a** symbol in the signal space or channel symbol[~~,~~]**)** is allocated to a bit sequence with a reversibly unambiguous, functional allocation. This symbol is subsequently mapped onto a signal curve (referred to below as signal value) allocated to this symbol. The functional allocation of a symbol to a bit sequence in the transmitter is called encoding or mapping; the mapping of such a symbol or of a plurality of such symbols onto a signal value is called modulation.

30 The reversal of this mapping sequence occurs in the receiver. [~~During the~~] **The** demodulation[~~, i.e.~~] **(i.e.,** the allocation of a reception signal to a symbol[~~,~~]**)** can usually not be implemented error-free due to distortions or superimposed disturbances of the channel, **however,** the decoding[~~, i.e.~~] **(i.e.,** the conversion of a detected symbol into the corresponding bit sequence**)** does not represent any

problems. Fig. 2 shows an inventive receiver that comprises a demodulator 10, a signal-to-noise ratio identification ~~[means]~~ **mechanism** 11 and an error rate identification ~~[means]~~ **mechanism** 12. The demodulator processes the received signal 13 in order to output a corresponding bit sequence 16 at its output. Such a demodulator 10 contains a decision unit 18 that allocates one or more symbols 9 or~~[, respectively,]~~ the corresponding signal value 15 to the edited reception value 14 following the analog and the optional first steps of the digital signal processing (combined here to form the block "signal editing" 17). The signal-to-noise ratio identification ~~[means]~~ **mechanism** 11 shown in Fig. 2 contains two different identification devices 20, 21 in order to identify a signal-to-noise ratio 22. An error rate 23 is allocated to the identified signal-to-noise ratio 22 in the error rate identification ~~[means]~~ **mechanism** 12 dependent on the respective encoding method.

31 Fig. 3 shows the structure of an inventive demodulator in the receiver of a digital transmission system. The signal 13 received from the transmission channel 4 is supplied to a signal editing device 17 that, for example, contains the analog-to-digital conversion needed for the digital signal processing and/or a distortion correction of the transmitted signals. The edited signal values 14 are subsequently supplied to the position unit 18 that, using this signal value, decides which symbol or symbols were most probably transmitted. The selected symbol or symbols 9 are conducted to the decoder 19 by the decision unit, ~~[said]~~ **the** decoder 19 converting the symbols 9 into the bit sequence 16.

32 The representation of the symbol values at the output 15 of the decision unit 18 shown in Fig. 2 or~~[, respectively,]~~ Fig. 3 is identical to the corresponding signal values of the detected symbol, i.e.**,** the signal values predetermined by the modulation in the transmitter. This signal value sequence 15 which is based on the detected symbols 9 is simultaneously forwarded - together with the detected signal value 14 - to a signal-to-noise ~~[ration]~~ **ratio** identification ~~[means]~~ **mechanism** 11 and/or to the preceding signal editing unit 17.

33 Such a signal-to-noise ratio identification ~~[means]~~ **mechanism** 11 is shown in Fig. 4. The illustrated identification ~~[means]~~ **mechanism** contains two versions (version 1, version 2) for calculating the signal-to-noise ratio 22. In an inventive receiver, it suffices to identify the signal-to-noise ratio in only one way.

34 Whereas the detected signal values 14 contain a signal part and a noise part, the signal values 15, which were identified based on the detected symbols 9, contain only the signal part. In both alternatives (version 1, version 2), the signal part S is divided by the noise part N (noise) in a division device 28 in the signal-to-noise ~~[ration]~~ **ratio** identification ~~[means]~~ **mechanism** 11. To this end, the average signal part S and the average noise power N must be respectively present independently of one another. The average signal power S is identified in the device 24 for determining the average power, ~~[being]~~ **which is** identified from the signal values 15 both according to version 1 as well as according to version 2.

35 For determining the noise power N, the signal part must be subtracted from the combined signal and noise part of the signal values 14. To that end, the signal values of the reference signal 15 are subtracted from the detected signal values 14 in the first embodiment (version 1) in order to obtain the noise signal values. The noise signal values are converted into the average power N, 27 of the noise signal in the device 25 for determining the average power.

36 In the second alternative embodiment, version 2, the average power S + N of the received signal values 14 is first calculated in the device 29. Subsequently, the average power of the signal part calculated in the device 24 is subtracted in the subtraction device 30. The average powers S and N or, respectively, 27 are conducted to the division device 28 that forms the ratio of the average powers of signal part S and noise part N~~[, what is referred to as]~~ **(**the signal-to-noise ratio (SNR) 22**)**. This signal-to-noise ratio (SNR) indicates the quality of the transmission of digital information via the transmission channel. Since, differing from analog transmission signals, one does usually not speak of signal-to-noise ~~[ration or, respectively, signal-to-noise]~~ ratio SNR ~~[[sic] given]~~ **for** digital transmission channels but generally utilizes the bit error rate or symbol error rate for evaluating the quality of a transmission system, a device 12 is inventively provided that converts the identified signal-to-noise ratio 22 into the generally standard symbol error rate (or bit error rate) 23. To that end, the identified SNR value 22 is converted into the desired symbol error rate 23 with a known mapping rule 24 in Fig. 5.

37 The mapping rule ~~[to be respectively]~~ employed is dependent on the encoding method and modulation method employed. A few known characteristics for converting the signal-to-noise ratio SNR into the probability for a symbol error P_M are

shown in Fig. 6[~~. Each~~]**, in which each** characteristic [~~thereby~~] corresponds to a different encoding method[~~.~~]**:** M [~~thereby~~] denotes the plurality of different possible signal values, QAM and PSK stand for different encoding methods; PSK denotes "phase shift keying" and QAM stands for quadrature amplitude demodulation.

[~~Abstract~~] **38 The above-described method and transmission system are illustrative of the principles of the present invention. Numerous modifications and adaptations will be readily apparent to those skilled in this art without departing from the spirit and scope of the present invention.**

~~[Method and Apparatus for Measuring the Transmission Quality of a Transmission Channel]~~ **ABSTRACT**

39 The transmission quality, particularly the symbol or~~[, respectively,]~~ bit error rate, that a digital transmission channel makes available can be determined with traditional methods in that a known bit or~~[, respectively,]~~ symbol sequence that is also known to the receiver is transmitted. The error rate can then be determined in the receiver by a rated-actual comparison. Inventively, an online measured value of the transmission quality is determined in that the signal-to-noise ratio of the average powers of an undisturbed and of a disturbed signal is formed. The symbol or~~[, respectively,]~~ bit error rate can be calculated from the signal-to-noise ratio. The quality measurement is based ~~[thereon]~~ **on the fact** that signal values from the set of signal values that are also valid in the receiver are allocated anew to the detected symbols in the receiver, and these signal values are subsequently compared to the actually transmitted signal values.

~~[Figure 2]~~